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(54) End arm manipulator

(57) An end arm manipulator includes a base, an arm pivotably mounted to the base and a workpiece interfacing member coupled to the arm. In another aspect of the present invention, multiple arms are coupled to the base and are movable independent of each other. In still another aspect of the present invention, generally spherical balls are adjustably mounted between a clamping member and a cavity of the base.

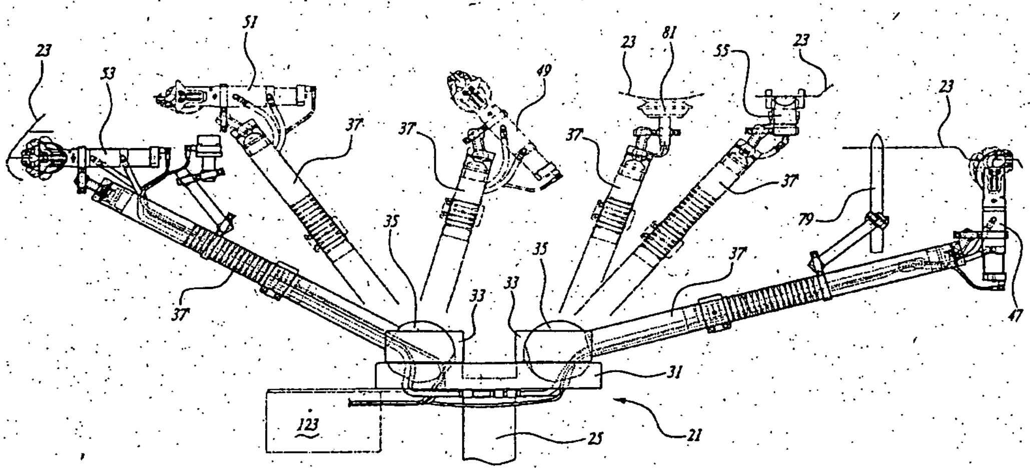

Fig-2

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Description

[0001] This invention relates generally to workpiece interfacing apparatuses and more specifically to an end arm manipulator for retaining workpiece interfacing tools.

[0002] It is common to employ fluid powered grippers for engaging sheet metal workpieces. Such grippers are often movably mounted to a robotic or stationary support. Examples of such mounting arrangements are disclosed in the following U.S. Patent Nos.: 5,647,625 entitled "Gripper" which issued to Sawdon on July 15, 1997; 5,383,738 entitled "Ball Jointed Links" which issued to Herbermann, on January 24, 1995; and 5,071,309 entitled "Mounting Arrangement for a Multi-Function Arm" which issued to Herbermann on December 10, 1991.

[0003] Another traditional device is constructed of multiple, extruded metal rails bolted to a generally square shaped frame. The frame is centrally attached to a moving robotic arm. Hoses extend from the hollow, box section rails which are used as air manifolds. Pneumatically powered grippers are adjustably mounted to various points on the rails. However, these traditional devices are custom fabricated for each particular job, are costly to produce and labor intensive to set up. These traditional devices require excessive amounts of actuating fluid due to the indirect right angle mounting of components and due to the use of rails as manifolds. Such conventional units are also relatively heavy and inefficiently packaged thereby causing accurate repeatability concerns, and a circuitous routing of electrical and pneumatic lines which are prone to snagging on adjacent equipment or the workpiece.

[0004] In accordance with the present invention, the preferred embodiment of an end arm manipulator includes a base, an arm pivotably mounted to the base and a workpiece interfacing member coupled to the arm. In another aspect of the present invention, multiple arms are coupled to the base and are movable independent of each other. In still another aspect of the present invention, generally spherical balls are adjustably mounted between a clamping member and a cavity of the base. The arms are telescopically extendable in a further aspect of the present invention. Yet another aspect of the present invention provides a fluid powered gripping tool or locating tool mounted on either an end or intermediate portion of an arm. Another aspect of the present invention provides a fluid manifold function as an integral part of the base.

[0005] The end arm manipulator of the present invention is advantageous over conventional constructions in that the present invention is quickly and easily adjusted for different workpiece set ups utilizing single or multiple arms in standardized packages. This eliminates the cost of individual fabrications and is reusable for other jobs. The present invention is also much more rigid than traditional devices since the present invention manipulator's arms directly extend between a compact base and the workpiece, as compared to the traditional right angle geometry. The straight geometry construction of the present invention is also more easily packaged in a small work space while further shortening fluid lines and electrical lines. Moreover, the straight or direct geometry construction reduces the volume of fluid consumed compared to the conventional right angle and box framed structure. The majority of the electrical and fluid lines are also advantageously protectively contained within the arms. Additional advantages and features of the present invention will become apparent from the following description and appended claims, taken in conjunction with the accompanying drawings, which are now briefly described:

Figure 1 is a perspective view showing the preferred embodiment of an end arm manipulator of the present invention gripping a workpiece;

Figure 2 is a side elevational view showing the preferred embodiment end arm manipulator in multiple positions and with multiple other preferred workpiece interfacing tools;

Figure 3 is an enlarged and fragmentary side elevational view showing a base, clamp rings, balls and arms of the preferred embodiment end arm manipulator;

Figure 4 is a fragmentary bottom elevational view showing the base, clamp rings, balls and arms employed in the preferred embodiment end arm manipulator;

Figure 5 is an enlarged cross sectional view, taken along line 5-5 of Figure 4, showing the base, a clamp ring and a ball employed in the preferred embodiment end arm manipulator; and

Figure 6 is a fragmentary and exploded perspective view showing the clamp rings, balls, arms and base employed in the preferred embodiment end arm manipulator;

Figure 7 is an enlarged cross sectional view, taken along line 7-7 of Figure 4, showing the base employed in the preferred embodiment end arm manipulator;

Figure 8 is an enlarged and fragmentary side elevational view showing an arm, tube clamp and tool mount employed in the preferred embodiment end arm manipulator;

Figure 9 is an exploded perspective view showing the tool mount and a side elevational view showing a workpiece interfacing tool employed in the preferred embodiment end arm manipulator; and

Figure 10 is an enlarged side elevational view showing the workpiece interfacing tool, a tool mount and the arm employed in the preferred embodiment end arm manipulator.

[0006] Referring to Figures 1 and 2, the preferred embodiment of an end arm effector or manipulator 21 is

used to retain or transport a workpiece 23, such as a stamped steel, body side frame of an automotive vehicle, within a manufacturing plant. A robotic arm 25 is centrally bolted to end arm manipulator 21 for moving the manipulator and selectively engaged workpiece to various positions in the factory. Alternately, end arm manipulator 21 can be mounted to a manually moved support or stationary structure mounted to the factory floor.

[0007] End arm manipulator 21 includes an aluminum base 31, four aluminum clamp rings 33, four predominantly spherical balls 35, four telescoping arms 37 and workpiece interfacing tools as well as their associated mounts. Additional preferred arms 37', workpiece interfacing tools and their associated mounts are shown in Figure 2. Exemplary preferred tool configurations include grippers 41, 43, 45, 47, 49, 51, 53 and 55, which each include a circular cylindrically shaped body 71 (see Figure 9), an internally disposed pneumatic driven piston 73 and at least one moving jaw 75 for gripping the workpiece. Grippers 41-53 employ one or more pivoting jaws of the type known as the BTM PG-45 style flange gripper, double opening gripper or fixed gripper. Gripper 55 is of a parallel or box jaw type gripper known as the BTM SSLG style gripper. Other preferred workpiece interfacing tools include an electromagnetic coil proximity part-present sensor 77, a steel locator pin 79 and a vacuum cup 81.

[0008] The construction of base 31, clamp rings 33 and balls 35 can best be observed in Figures 3-6. Each clamp ring 33 is a C-shaped member having a side opening 101 and a top opening 103 through which arm 37 and a portion of ball 35 extend, respectively. Each clamp ring 33 further has an internal partially spherical cavity 105 for receiving the respective ball 35. Each corner of base 31 also has a partially spherical cavity 107 for receiving a corresponding ball 35. Bolts 109 are employed to loosely secure each clamp ring 33 to base 31, whereupon the corresponding ball trapped therebetween is pivotally adjusted to a desired orientation. After such a desired set up orientation is achieved, bolts 109 are tightened so as to secure and maintain the respective ball 35 and arm 37 in the final setup position. It should be appreciated, however, that each clamp ring 33 can be unbolted from base and rotated to many different rotational positions such that side opening 101 of each clamp ring 33 can be differently angled relative to base 31. If necessary, a dowel or screw can be inserted into aperture 121 in each clamp ring 33 for supplementally securing the corresponding ball 35 in its ultimately desired position.

[0009] A NEMA box 123 is fastened to the bottom of base 31 for containing electrical line or wire connections and controllers. Furthermore, the robotic arm is bolted to a central area 125 of base 31.

[0010] A manifold portion 141 of base 31 can be seen in Figures 4 and 7. Manifold portion 141 is integral with base 31 and includes a pair of longitudinally elongated bores 143 and multiple transversely extending passageways 145 intersecting each bore 143. Bores 143 and passageways 145 are all drilled into base 31 although alternately, they may be integrally cast. It may be desired to thread the open ends of bores 143 and passageways to accept standard fittings. The main pneumatic fluid lines or hoses are coupled to the open ends of bores 143 while the individual tool pneumatic lines or hoses are connected to the open ends of respective passageways 145. Thus, manifold portion 141 of the present invention acts as a very compact, centralized and integral fluid receiving and distributing device.

[0011] Referring now to Figures 3, 6 and 10, each arm 37 is hollow and MIG welded to a corresponding ball 35 aligned with a first hole 201 in ball 35. Ball 35 is made as two separate and generally semi-spherical spun halves that are TIG welded together at TIG weld 203. Arms 37 and balls 35 are both made of steel. For each workpiece interfacing tool 47, two pneumatic lines 205 are routed from manifold portion 141, up through a lower hole 207 in base 31 and through a second downwardly facing hole 209 in ball 35. Pneumatic lines 205 are then routed in arm 37 and are allowed to exit through a laterally extending aperture 211. These pneumatic lines are then coupled to each fluid powered tool 47 for automatically and remotely activating the tool to grip or disengage workpiece 23. One or more electrical lines 231 are routed from box 123, up through hole 207, hole 209 and then in arm 37. Electrical lines 231 also exit arm 37 through aperture 211 and are then connected to a Turck switching or position sensing unit 233 mounted to tool 47.

[0012] Figure 8 illustrates the telescopic nature of arm 37. Arm 37 includes a proximal arm section 401 and a distal arm section 403. Distal arm section 403 has a slightly smaller outside diameter as compared to the inside diameter of proximal arm section 401. Thus, distal arm section 403 can be longitudinally slid into and out of proximal arm section 401 depending upon the desired set up length. Furthermore, distal arm section 403 can be rotated relative to proximal arm section 401 depending again upon the desired set up positioning; 360° distal arm section rotational movement is allowed. A tube clamp 405 engages the outside surface of proximal arm section 401 and serves to maintain the desired set up position of distal arm section 403 relative to proximal arm section 401 by tightening of screws 407. Four inwardly extending tabs of tube clamp 405 serve to slightly compress and crush the adjacent area of proximal arm section 401 thereby frictionally engaging a roughened outside diameter surface of distal arm section 403. If necessary, a dowel pin 409 or screw can additionally secure the arm sections relative to each other. Figure 8 also shows an intermediate arm positioning of a tool mount 411 along a generally middle or intermediate portion of arm 37.

[0013] An exemplary tool mount 451 is shown in Figures 9 and 10. Mount 451 includes a ball and socket

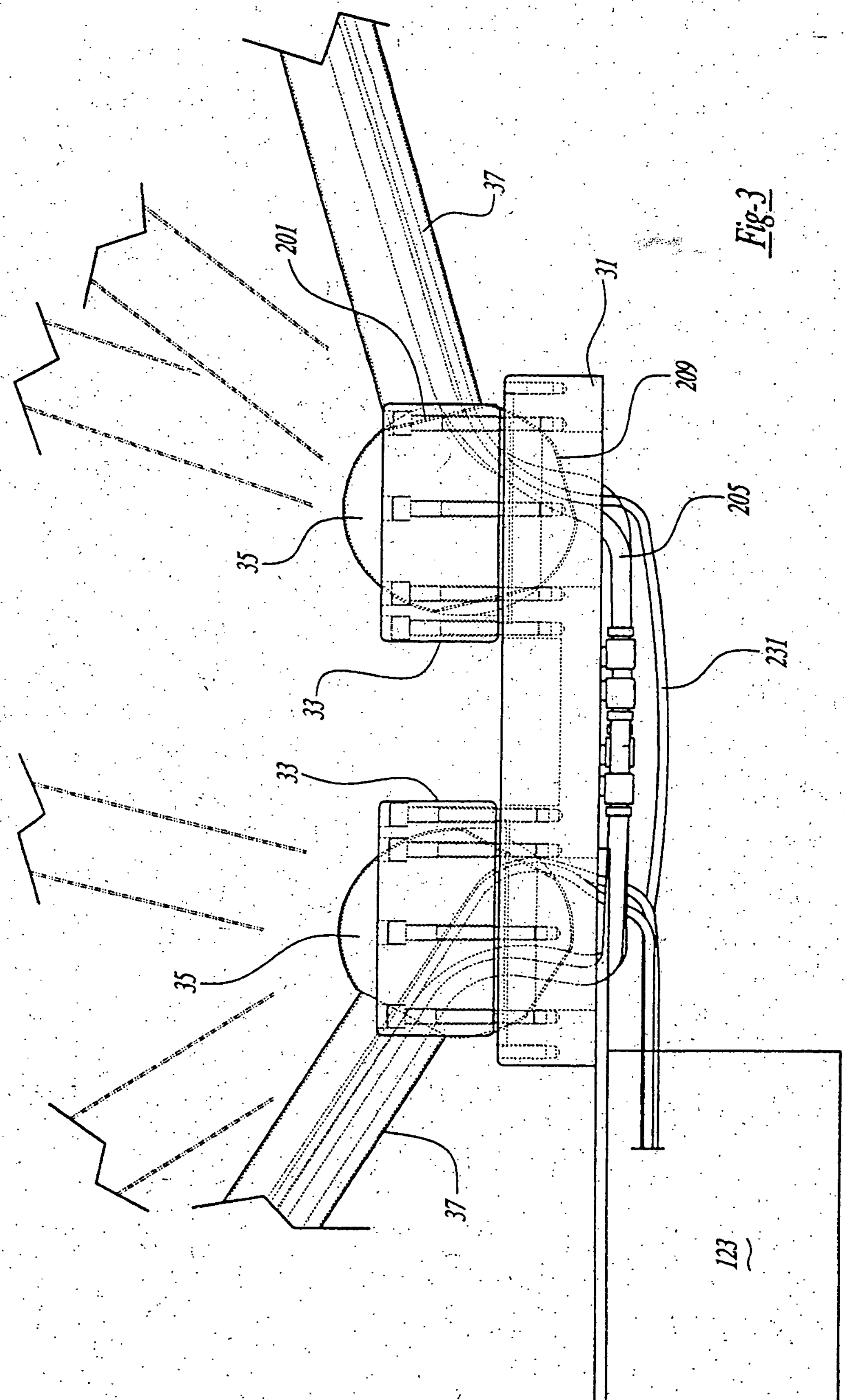

Fig-3

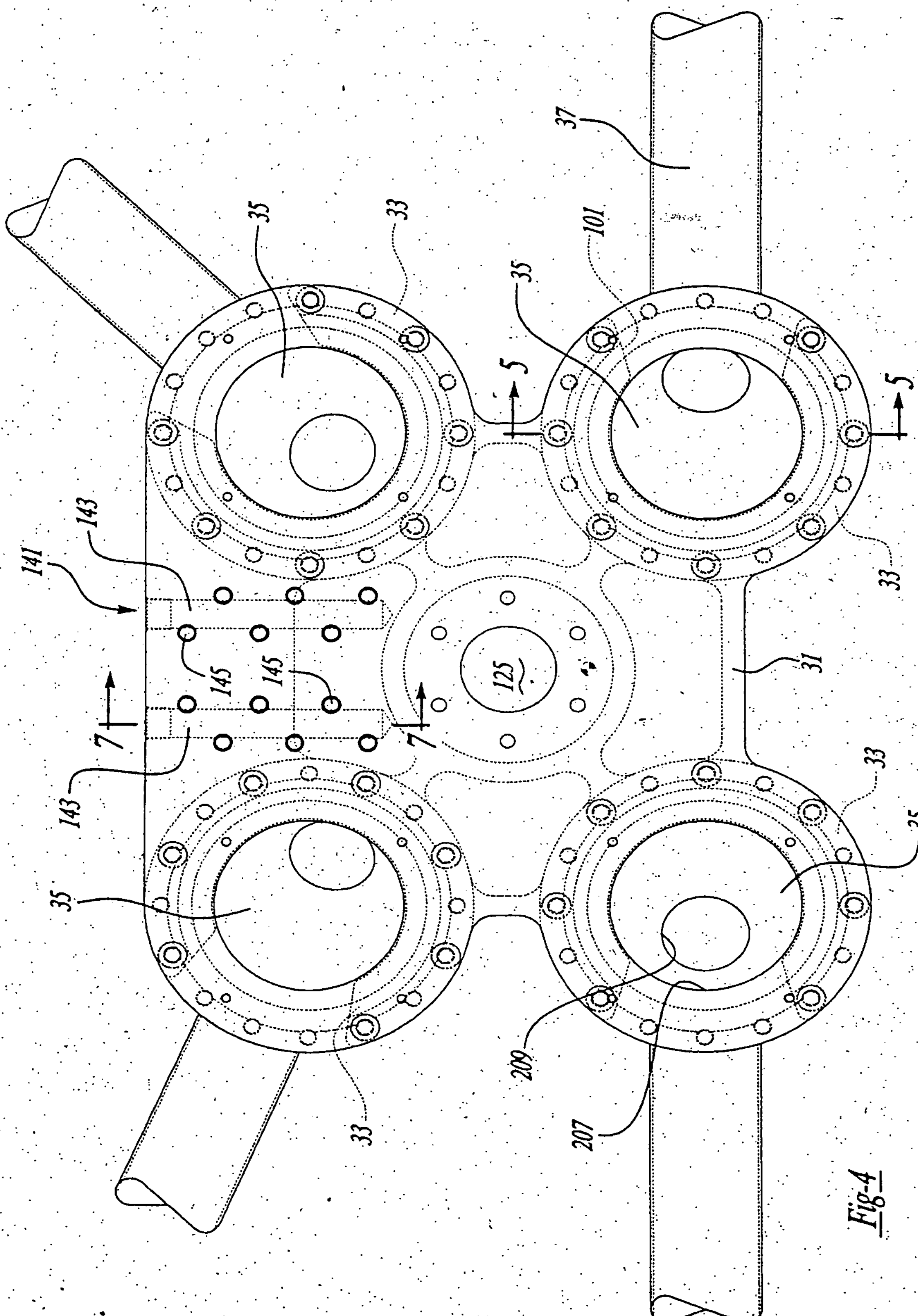
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Fig-4

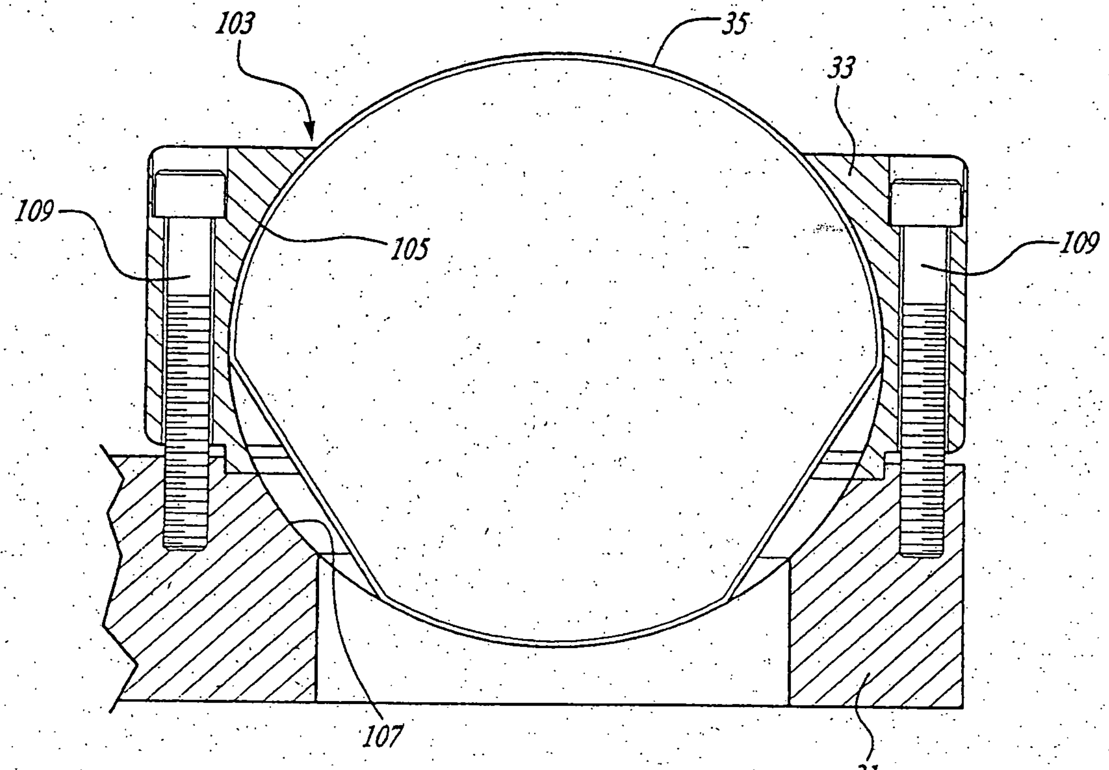

Fig-5

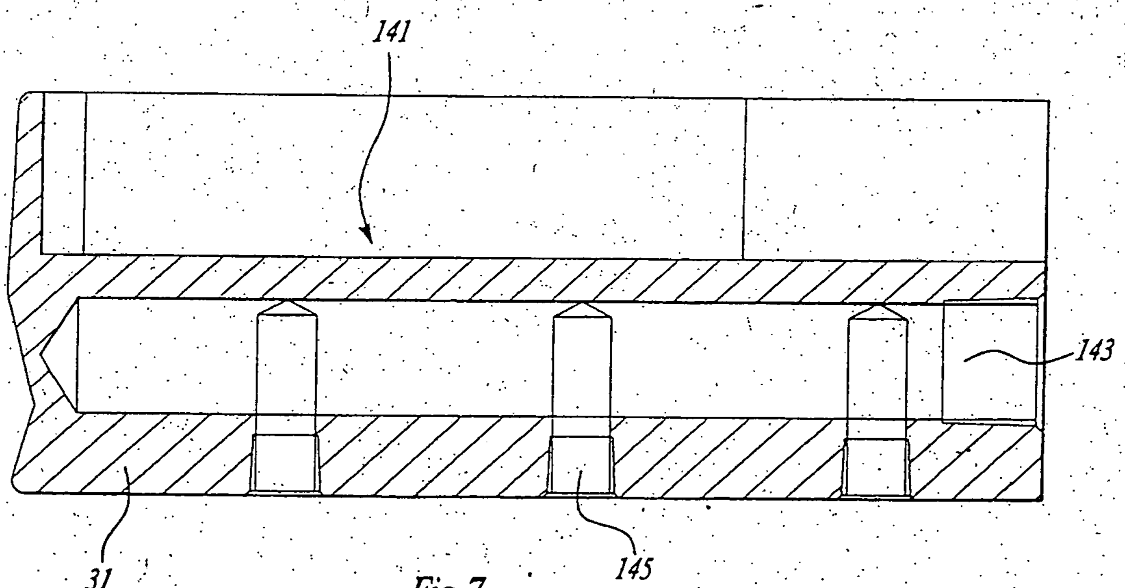

Fig-7

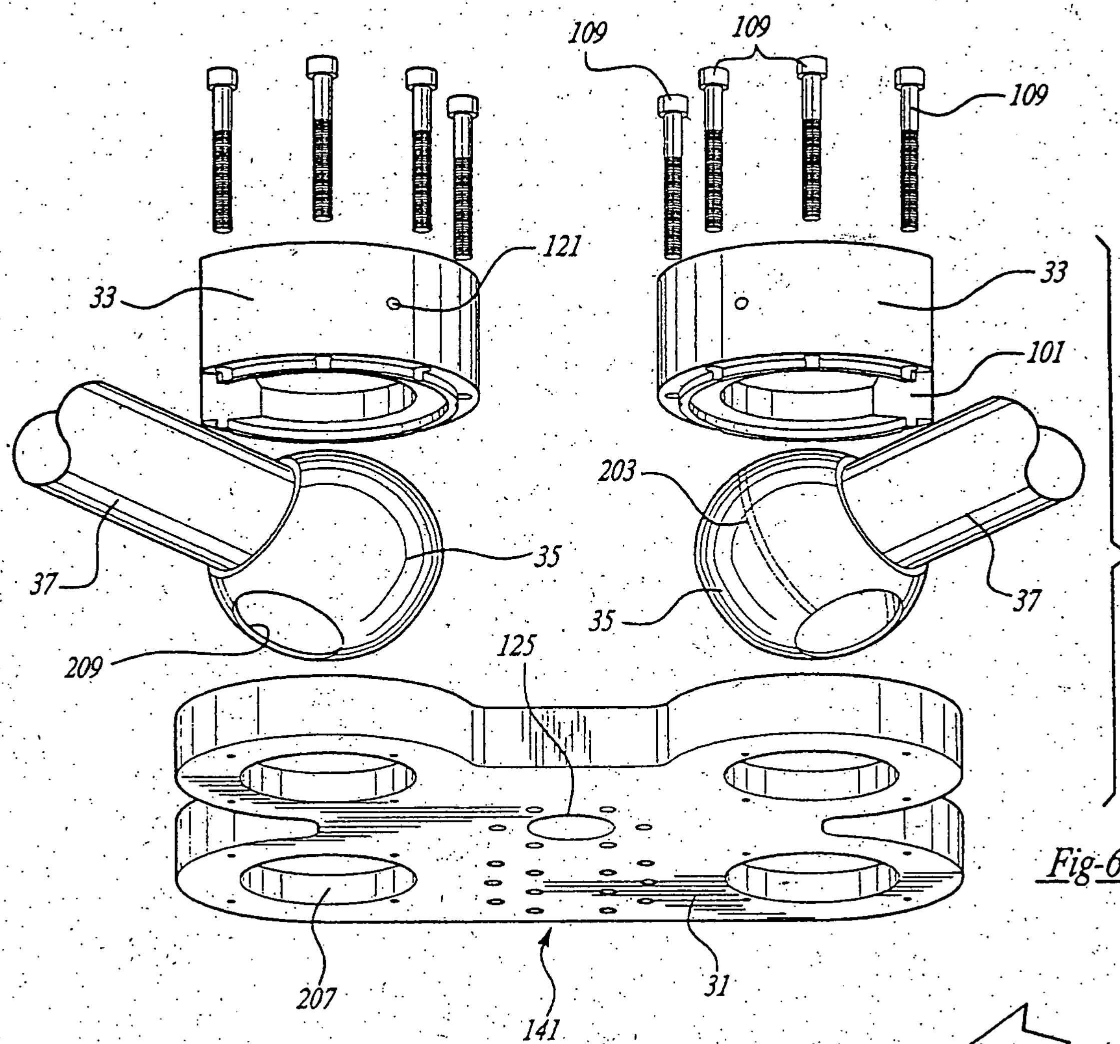
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Fig-6

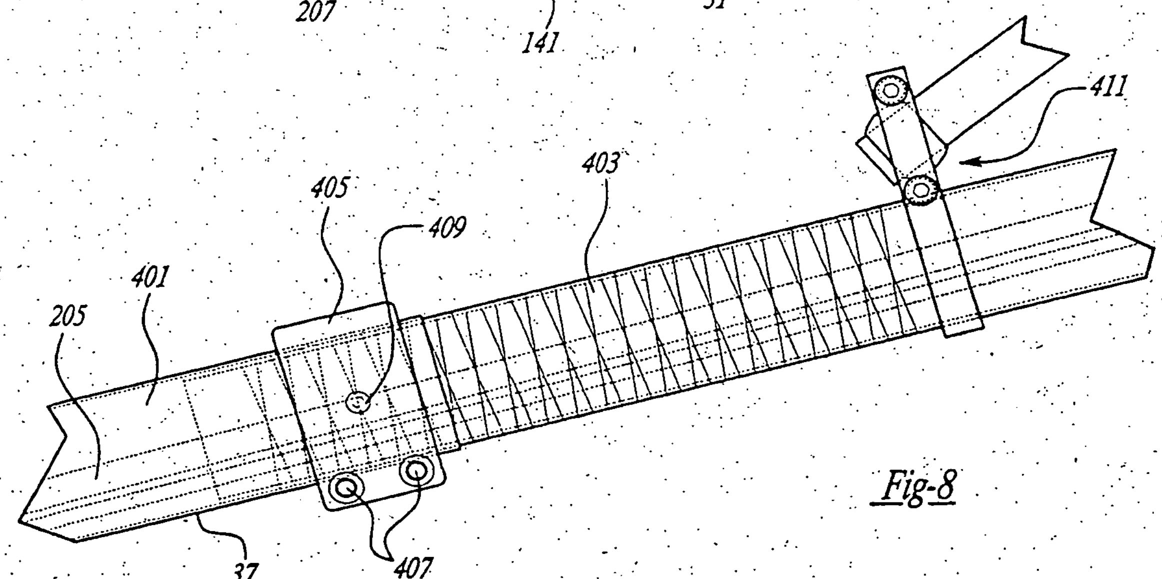
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Fig-8

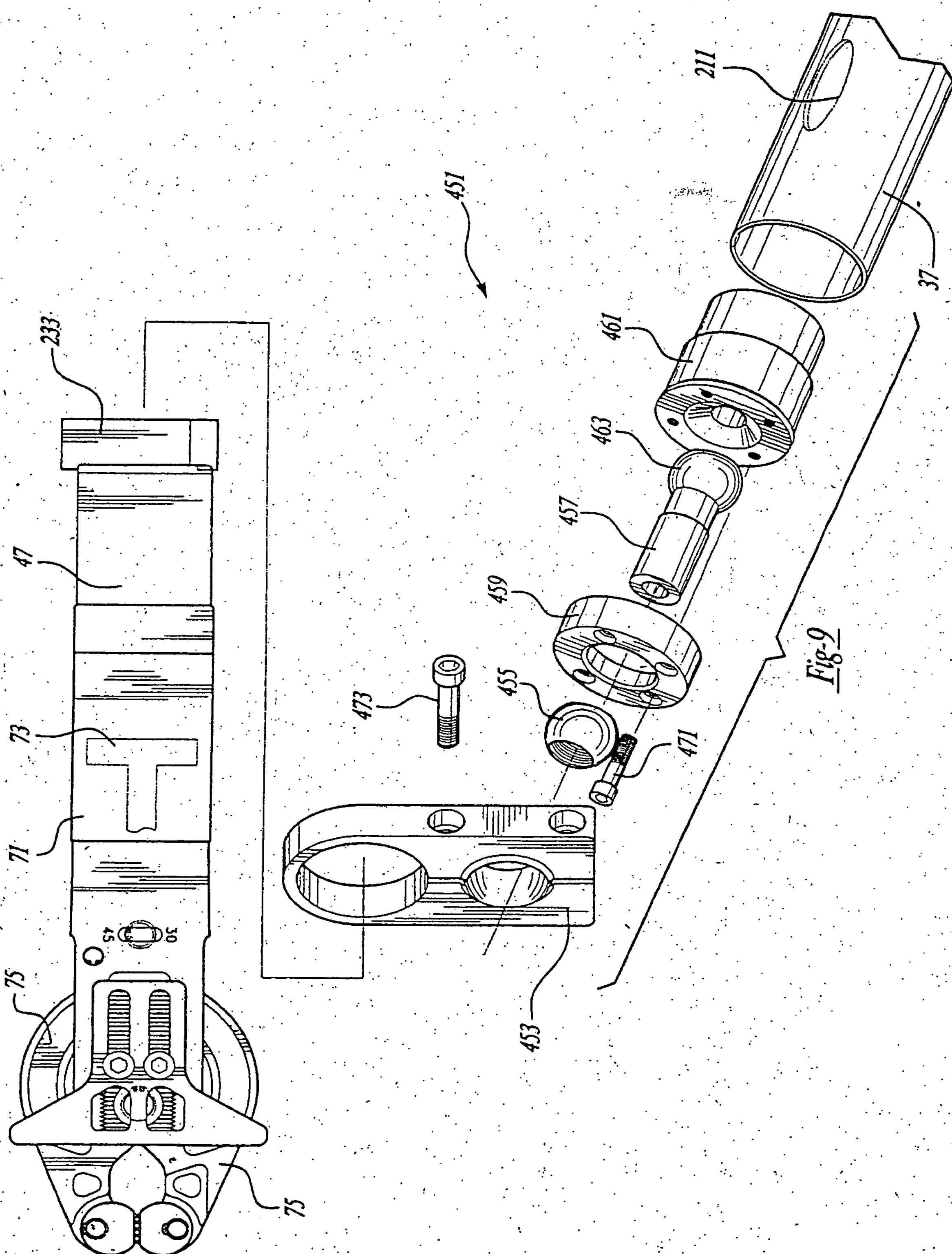

Fig-9

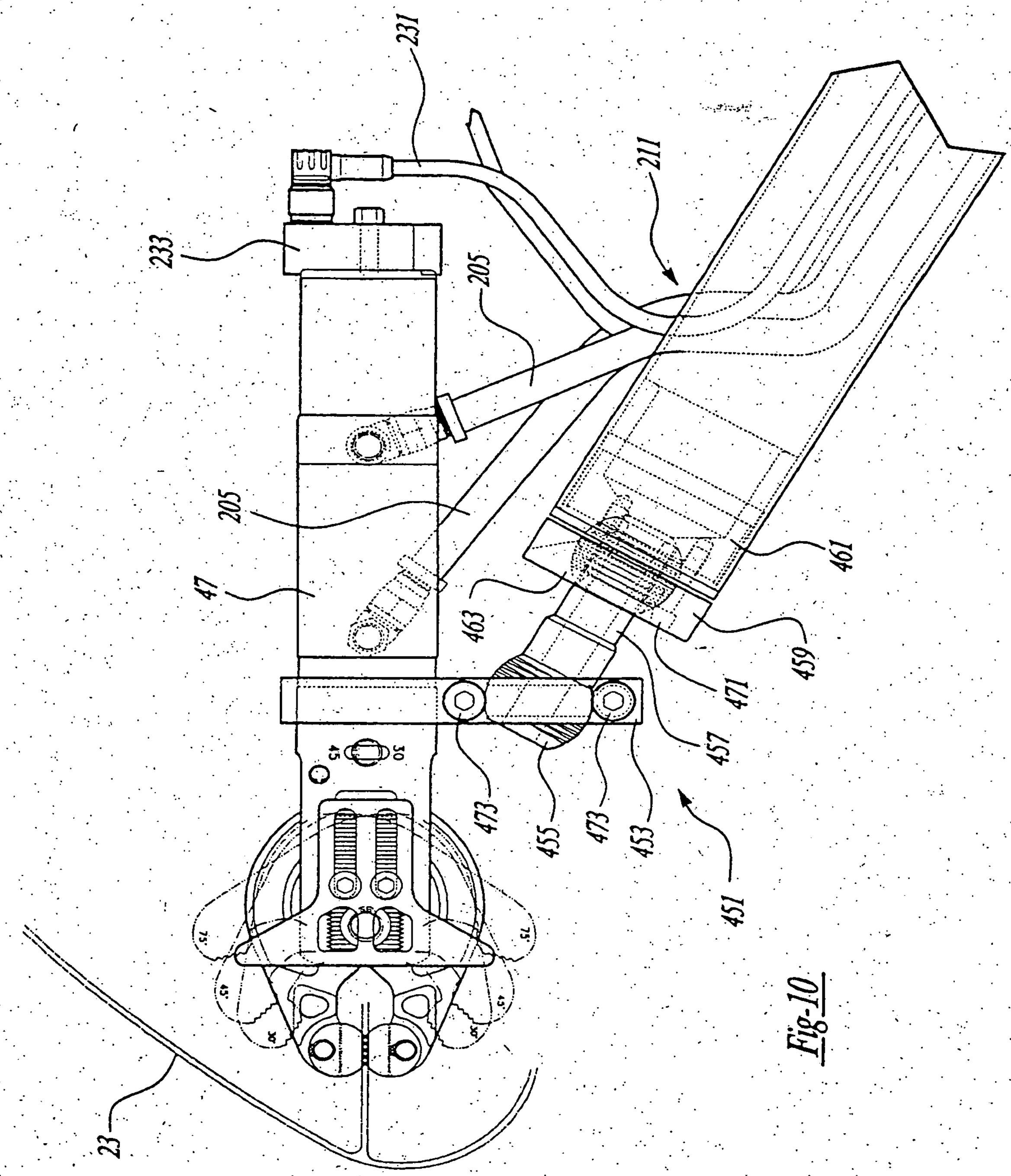

Fig-10